# Smart Spaces to Go

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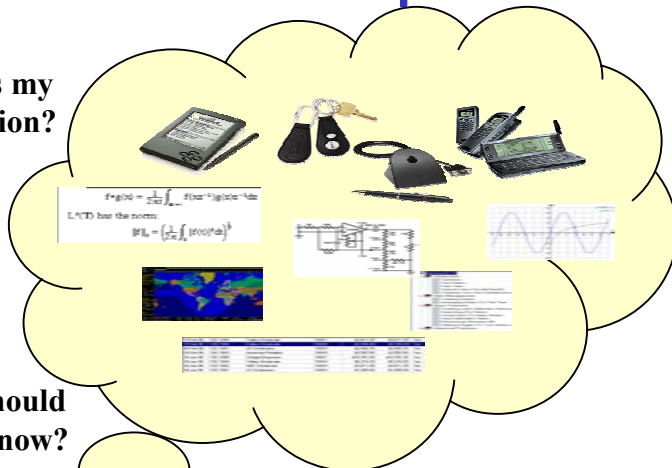# Smart Spaces to Go

**Enable mobile workers to use multiple devices in different work places for different tasks.**

Where is my information?

What device should I use here and now?

How do I get the information to the right device in the right format?

## New Capabilities

- Critical information follows users moving among locations

- System dynamically composes suitable multi-device, multi-mode interfaces as users move among locations

- Information adjusts interaction and presentation to devices available at each location

**Integrating people with physical spaces and information spaces**

# Smart Spaces to Go

## People work and live on the move

**Rescue Workers**

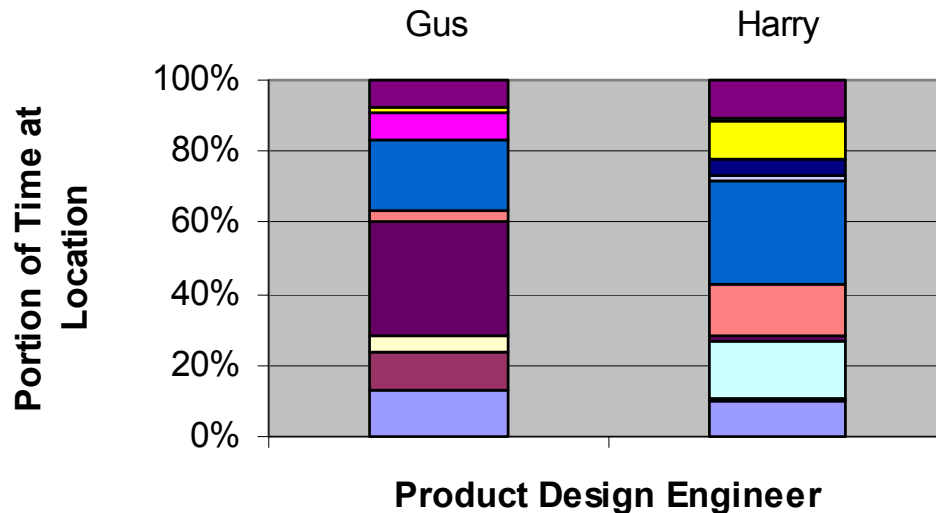**Doctors**

**Soldiers**

**Police Officers**

**Factory Workers**

**Sailors**

**CIO for a major airline notes that 85-90% of the airline's workers are mobile information workers who spend most of their time away from their "designated" work place.**

# Smart Spaces to Go

## Mobility Over Four Working Hours

Gus    Harry

**Portion of Time at Location**

100%
80%
60%
40%
20%
0%

**Product Design Engineer**

### In How Many Locations?

Source: Bellotti and Bly study of distributed collaboration in a product design team, Proceedings CSCW 96.

- **10-13% of work completed at desktop**

- **76-82% of work spread between 11 other locations**

- **8-11% of time spent moving between locations**

# Smart Spaces to Go

## How do people on the go interact with information today?



Growing population of portable, embedded, wearable computing devices, each specialized for particular tasks, but

• User interacts with each device independently

• Many applications are vertically integrated with devices

• User must track, convert, and transfer information across devices

# Smart Spaces to Go

**Device overload will swamp the user,
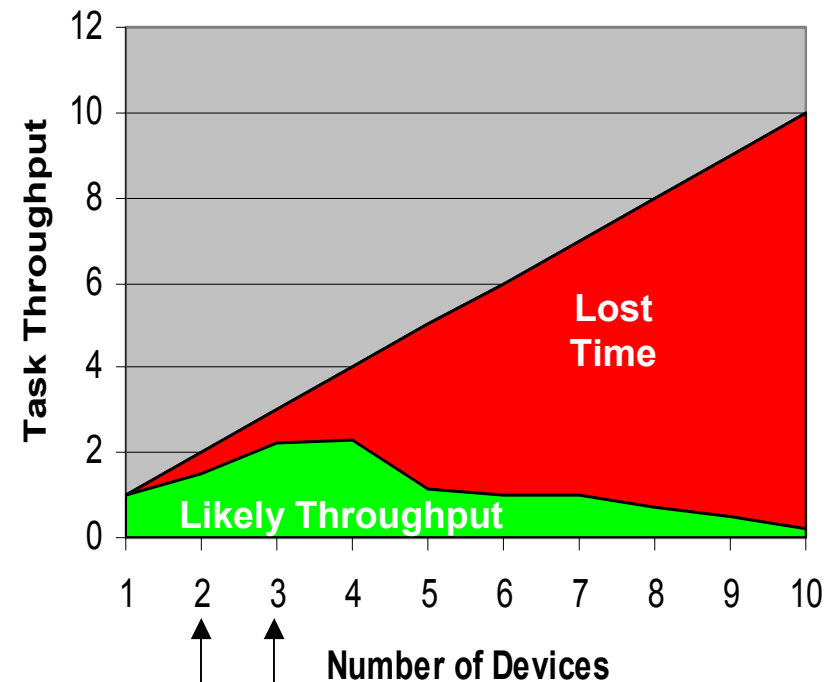even in the absence of underlying information overload.**

- **Which device(s) should I use here and now?**

- **Where is the information I need?**

- **How do I get the information to the right device and in right format?**

**Where will most users be on this curve?**

**Effects of Device Overload**

**Task Throughput**

**Lost Time**

**Likely Throughput**

**Number of Devices**
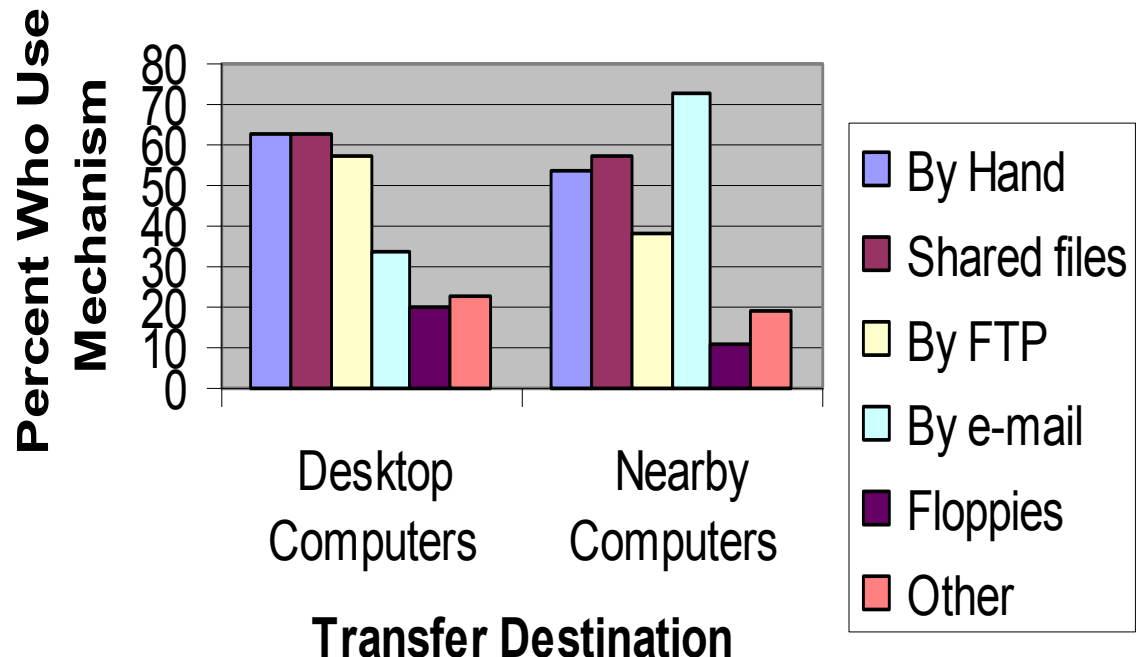
**Average Savvy Professional**

**Geek and Nerd**

## More Computers, More Unproductive Time

- **Computers on desktop: 54%= 3; 39%= 2; 7% =1**

- **Transfer data between desktop computers: 70% very often and 25% often**

- **Transfer data between nearby computers: 28% very often; 23% often; 36% sometimes**

Source: Jun Rekimoto, study of software engineers Proceedings of the ACM Symposium on User Interface Software Technology (UIST), 1997

### How Do Software Engineers Transfer Information Among Computers?



**Percent Who Use Mechanism** (y-axis, 0–80)

Transfer Destination: Desktop Computers, Nearby Computers

Legend:
- By Hand
- Shared files
- By FTP
- By e-mail
- Floppies
- Other

## Two Things Have Changed

### 1. Networking-capable PDAs, Sensors, and Devices

*IrDA and Blue Tooth Wireless LANs and Fire Wire and USB Plug-and-Play Buses*

### 2. Location-aware Devices

*GPS, Cell Phones, Active Badges*

# Smart Spaces to Go

**DARPA** can exploit this changing situation by developing software solutions to **three hard problems**:

**1** Coordinating interactions across tens of heterogeneous devices and between seven to ten modes

**2** Managing information mobility on a geographically significant scale

**3** Adapting information delivery using knowledge of people, places, and devices

# Smart Spaces to Go
## Coordinating Interactions

**New Idea: Poly-Device, Poly-Modal Interface**

**A distributed coordination bus that:**

• **shares interaction events among networked groups of devices**

• **dynamically composes interfaces optimized for tasks, modalities, and devices**

| Decentralized Approach | Federated Approach | Centralized Approach |
|---|---|---|
| *Multicast Event Bus* *Announce/Listen Protocols* *Squawking Discovery Protocols* | *Reflector Event Bus* *Subscribe/Listen Protocols* *Push Discovery Protocols* | *Bulletin Board Server* *Registration Protocols* *Query Discovery Protocols* |
| **MASH - UCB** **Visage-Link** | **Habanero -NCSA** **Orbit** **MAW** | **DISCIPLE - Rutgers** **Java Beans** **Jini** |

# Smart Spaces to Go

**Tens of Devices**

| | | |
|---|---|---|
| PDAs | Head Trackers | A/V Switches |
| Desktops | Projectors | Light Switches |
| Notebooks | Pens | Smart Cards |
| Large Screen Displays | Cross Pads | Active Badges |
| Head-worn Displays | Pointers | Speakers |
| Eye Trackers | Cell Phones | iButtons |
| Cameras | Motion Sensors | . . . |
| Microphones | Bar Code Scanners | |

# Smart Spaces to Go

**Seven to Ten Interaction Modes**

Visual Display

Audio Output

Speech Input

Keyboard Input

Gaze Input

Gesture Input

Mouse Input

Pen Input

Touch Input

Haptic Output

# Smart Spaces to Go
## Managing Information Mobility

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**New Idea: Active Information**

**Systems of mobile, replicable objects that communicate as groups to:**

• **track location, state, and trajectory of information**

• **track location, state, and trajectory of users**

• **plan information movement and replication**

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| Multicast Tracking | Geographical Tracking | Identity-Based Tracking |
|---|---|---|
| *Context Dependent Routing*<br>*Bi-directional Device Beaconing*<br>*With Intelligent Buttons* | *Location Dependent Routing*<br>*Query Global Positioning*<br>*With Smart Cards* | *Address-based Routing*<br>*Query Active Badges*<br>*With Speaker Identification* |
| **BARWAN -UCB**<br>**Active Services** | **Infostation - Rutgers**<br>**Stanford**<br>**Open Market** | **Piconet - ORL**<br>**BBN** |

# Smart Spaces to Go
## Adapting Information Delivery

**New Idea: Inter-Space**

**Couple sensor data with resource and scene description languages to model physical and logical space, so that software can:**

- **exploit location, proximity, visibility of resources to determine delivery devices**

- **adapt presentation to characteristics of available devices and services**

| Device-Based Modeling | Image-Based Modeling | Graph-Based Modeling |
|---|---|---|
| *Embedded Device Descriptions* *Device Description Diffusion* *Proxy-based Transcoding* | *Physical Model Construction* *Image Sensor Mapping* *Visibility Algorithms* | *Installable Descriptions* *Wizard-Configured Maps* *Graph-based Algorithms* |
| **MASH -UCB** **Active Services** | **City Scanning - MIT** **Building Scanning - UCB** | **Jini - Sun** **Active Directory - MS** |

# Smart Spaces to Go

## Increased Information Availability

**Responding to Emergencies**

**Saving Lives**

**In the Assault**

**On the Flight-Line**

**WIMP HCI**


**Smart Spaces HII**

# Going Our Way?